EFFORTS TO ADDRESS URBAN STORMWATER RUNOFF

Statement of

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Good morning, Madam Chair and members of the Committee. My name is Robert Traver. I am a Professor of Civil and Environmental Engineering at Villanova University, Director of the Villanova Urban Stormwater Partnership, and served as a member of the National Research Council (NRC) Committee on Reducing Stormwater Discharge Contributions to Water Pollution. The Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. I have been asked to focus on the utility of green infrastructure and low impact design approaches in mitigating urban stormwater runoff, to identify barriers in implementing these approaches, and recommendations for alleviating these barriers. My testimony will address each of these in order.

...utility of green infrastructure and low impact design approaches...

As the NRC committee report states, although stormwater's contribution to water quality impairment has been known for many decades, only in the last 20 years have federal regulations addressed the issue. In order to protect our nation's waters, our expectations of stormwater management have shifted from solely a flood control perspective, to one of addressing water quality, water quantity and supply, aquifer recharge, base flow and stream channel protection, in addition to flood control. Consequently, this shift of goals has dramatically changed the approaches used to address these challenges. We have moved from detention strategies of simply storing the water during a major storm event, to natural control measures encompassing both small and larger storms. Our tool box of green infrastructure control measures has also grown, from measures as simple as reducing the amount of pavement used, or disconnecting drainpipes so that stormwater runs over the grass, to water reuse, and to engineered structures that integrate with nature, such as bioretention / bioinfiltration facilities, green roofs and pervious pavements.

Green infrastructure and low impact design to me are approaches that first reduce the creation of and then employ nature to address the detrimental impacts of urban stormwater. Rainwater collected in rain barrels or cisterns is a resource that can be used for irrigation, vehicle washing, or other uses, reducing runoff and the need for treated water. Natural runoff management practices incorporate the hydrological, physical, chemical, and biological processes of our soils, plants, and water bodies. These practices target runoff from impervious surfaces like pavements and roofs, and work together as an engineered system in meeting stormwater mitigation goals. Some, if not all of the control measures can be incorporated in the drainage infrastructure. As an example, Figures 1 and 2 below show two retrofit control measures at Villanova that are described in the NRC report. The green roof in figure 1 is designed so that approximately the first inch of rainfall is captured and evaporated such that it does not enter the stormwater drainage system and ultimately impact nearby streams. From a small storm perspective, its hydrological properties would be similar to a meadow or a forest. While not sufficient alone in addressing flood control during an extreme event like a hurricane, the green roof does provide a tremendous benefit in reducing runoff in areas like Seattle and Philadelphia where the great majority of storms average an inch or less. The green roof works by capturing rainfall, soaking it into a soil layer, and then using the plants and sunlight to evapotranspirate the water. Note that the green roof works well at Villanova due to our pattern of rain and climate, but may not work as well in other areas of the country. Figure 2 shows a bioinfiltration site also at Villanova. This stormwater control measure was constructed in an existing traffic island, and routinely captures 80 to 90 percent of the rainfall, and filters out over 95% of the particulates and sediment, by infiltrating the water through the soil. The plant's root structure aid in maintaining pathways of infiltration, and the chemically and biologically active soil layer captures and treats most of the pollutants in the runoff (Davis et al 2009). Note that the pavement temperature effect is also reduced in this manner. Yearly only a handful of storms normally exceed the capacity of the control measure, and the site has shown no statistical reduction in performance over the last

Figure 1-Villanova Green Roof

Figure 2 - Villanova Retrofit Bioinfiltration Traffic Island

eight years (Emerson, Traver 2008). If more control is needed, overflow from these sites can be directed to a stormwater wetland, underground chamber or other detention facility. We should not forget that green infrastructure also makes use of constructed surfaces such as pervious pavements (Fig 3), and detention facilities such as stormwater wetlands.

Figure 3 - Pervious Concrete during a Storm Event

Any talk of utility needs to discuss the performance and maintenance of these stormwater control measures. Several documented successful LID / Green Infrastructure projects are discussed at length in the NRC report, including a LID subdivision in Jordan Cove, Connecticut that uses bioretention, bioswales and pervious pavements. Other effective projects include the use of bioinfiltration raingardens in Burnsville, Minnesota, Villanova's Stormwater Research and Demonstration Park, and bioswales in Seattle, Washington. All of these projects are similar in that the green infrastructure is incorporated in the pathways of the drainage infrastructure, thereby minimizing implementation costs, and reducing their footprint. My belief is if we had included the bioinfiltration control measure as part of the original traffic island construction at Villanova, it would have ultimately reduced construction costs due to the elimination of drainage piping and inlets. Maintenance practices at all of the Villanova sites have been found to be minimal and involve cutting and removing dead grasses at the end of the growing season, trash removal, weeding, and vacuum street sweeping of pervious pavements, activities that differ little from normal landscaping.

Research continues to document the benefits of low impact design and green infrastructure. From an engineering perspective they are the most cost effective and sustainable approach in mitigating the effects of urban stormwater runoff. These measures reintroduce hydrological processes lost during urbanization and, thus, are better able to meet the goals of the Clean Water Act.

... identifying barriers in implementing these approaches ...

As with any new approach or technology, there are barriers to implementation. Most of our current institutional and regulatory structures were developed without considering the quality aspects of urban runoff, and the subject was not included in our engineering curriculums until recently. Residents have grown accustomed to pipes and nicely mowed detention basins in their neighborhoods.

Institutional Barriers: - As stated in the NRC report, "*Because this longstanding environmental problem is being addressed so late in the development and management of urban areas, the laws that mandate better stormwater controls are generally incomplete and are often in conflict with state and local rules that have primarily stressed the flood control aspects of stormwater management."* The simplest examples are ordinances that mandate outdated practices like required curbing, house setbacks or large parking areas. More insidious are design codes that underestimate the performance of green infrastructure control measures, and fail to put their purpose in perspective. An example would be design requirements resulting in unnecessary enormous footprints for bioinfiltration / bioretention sites that would exclude their use in favor of more traditional and expensive and less sustainable alternatives.

Another institutional barrier rooted in the past is the separation of stormwater quantity and quality that has occurred in both the regulatory and scientific arenas. Unlike many types of polluted water, stormwater typically is characterized by rapidly changing and widely fluctuating flows and quality depending on the season, the land use and preceding storm events. The high flow rates and extended duration of urban stormwater runoff erodes stream channels, such that control measures that reduce these flows and high volumes are extremely important. Furthermore, any stormwater control measure that reduces volume has a positive impact on reducing the pollution associated with stormwater to include temperature. I have heard from several scientists and engineers that they do not favor green roofs as they export nutrients during larger storm events.

They miss the connection. If the roof captures and removes 90% of the rainfall, export of some nutrients in a handful of large events is not important, and natural wooded areas would also export nutrients during these same events.

Technology Barriers – The implementation of green infrastructure and low impact design has proceeded faster than our understanding and ability to predict the outcomes of the many processes involved. We know that these green infrastructure and low impact design practices are tremendously more effective than those used in the past. However what we are not able to do well is to predict the performance during a unique storm event, or understand with certainty how a grouping of green infrastructure practices can achieve our goals in a specific watershed. For example the most common measure of performance today is percent removal of a pollutant, and this metric has flaws. A very dirty storm event entering a control measure may have a great pollutant removal percentage, but what leaves could still be high enough to be detrimental. On the other hand runoff that is relatively clean entering, can meet water quality requirements but if used to measure the performance, it would lead to a poor removal percentage.

An engineering or science based approach requires understanding of the treatment and flow mechanisms involved. For bioinfiltration (Fig. 2), we need to quantify the evapotranspiration, the seepage through the surface, and the movement of stormwater through the soil. At the same time we need to understand the chemical and biological actions in the soil, how the soil incorporates the incoming pollutants, and the effects of seasonality. As you can imagine, expanding this to a small group of control measures, or scaling up to a county level, greatly increases the complexity of predicting their performance and the reliance on our understanding of the treatment and flow mechanisms.

Perception Barriers- The public perception of green infrastructure varies widely. At Villanova we have had thousands of visitors to our research sites. Groups have included engineers, scientists, public officials, school groups of all ages, facility managers and even garden clubs. Many of their questions reflect misperceptions about green infrastructure and low impact design. Frequently west nile virus and mosquitoes are of concern to the visitors, and they are surprised to learn these sites reduce the mosquito population if designed correctly. They envision bioswales and bioinfiltration sites to be always wet, when the opposite is true. Professionals with little to no experience with LID/green infrastructure assume construction and maintenance are unreasonably expensive, and that the control measures have short life cycles. With good design both of these are also untrue.

All of these barriers are amenable to solutions, as I will discuss next.

...recommendations for alleviating these barriers...

Any recommendation as to the removal of these barriers must be inclusive, and founded on a deeper understanding and consideration of all aspects of urban stormwater runoff. Solutions to institutional, technology and public barriers are interrelated, each supporting one another.

<u>Institutional Solutions</u>- The NRC report recommends a systems approach tailored to the watershed and implemented at the municipal level. This approach must incorporate land use and all stressors including urban runoff quality, quantity and temperature. Antiquated codes and design standards that preclude or inhibit green infrastructure and low impact design must be retired, and replaced with codes that allow the full potential of green infrastructure to be realized. The coupling of quality expectations to land use is a critical component.

Regulatory standards and performance metrics should be based on science. Clearly this includes the role of flow as a pollutant. The real or perceived inability to include flow within the regulatory process reduces the effectiveness and increases the cost of our mitigation efforts, and artificially promotes less sustainable practices. It is simply not scientifically possible to meet the goals of the Clean Water Act without targeting flow.

I believe green infrastructure / low impact design is the approach of choice for dealing with the impacts of urban stormwater, as it is the most protective and cost effective solution for the community, the property owner, and our waters.

Technology Solutions- A broad based research effort is needed to further our understanding of green infrastructure. This effort must reach across different climates (with consideration of climate change) and soil conditions, with a short term goal of predicting with reasonable accuracy the performance of an individual green infrastructure control measure for a specific storm event. This will enable the longer term goal of predicting the impact of green infrastructure from a larger watershed perspective. It is critical that these research efforts look past the current surface water perspective and include baseflow and groundwater effects as well.

To reach this goal requires a research effort integrating laboratory, field, and modeling studies. This research must include multiple long-term continuously monitored sites because the variability of performance, the effects on the surrounding environs, and maintenance and longevity issues can only be addressed with long-term research. Multiyear data will allow us to use more precise designs to lower the cost to the landowner and community, and to avoid investing millions on ineffective practices as has been done in the past. Monitoring multiple sites would allow the direct comparison of design components. It is also worthwhile to search out older green infrastructure projects to better understand the effects of aging. For example at Villanova we found two seepage pits that are estimated to be 80 to 100 years old, and preliminary studies of their continued capacity have changed the way we view longevity. Green infrastructure and low impact design have many other potential benefits beyond stormwater control that need to be substantiated. It is my understanding that cooling properties of a green roof aid the performance of solar panels, and both can be installed together. Rainwater use via water harvesting has an energy benefit. Carbon removal by green roofs, wetlands, bioswales, and bioinfiltration and bioretention sites may be a significant benefit as well. All of these additional benefits require substantiation.


Figure 4 – Villanova Stormwater Tour

Perception Solutions- The technology solutions also start to address the barriers in perception. Simply visiting LID and green infrastructure sites and seeing that they work and are good neighbors is key to changing perceptions. This has happened most effectively in the higher education arena, where students are hired to work on the projects, the concepts are introduced in their courses, and they see the technology in action every day. For example, at Villanova our new green dormitory is in the final planning stages with solar panels and green infrastructure practices. Every day leaving their dorm students will pass the bioinfiltration and bioretention control measures and see on a display the amount of power saved and urban runoff mitigated. This level of education could accompany new or retrofitted projects at schools, municipal buildings, and shopping centers, and would be key to engaging the community and greatly expanding their knowledge base. Redevelopment should be viewed as an opportunity to incorporate green infrastructures to areas of the U.S. where it has never existed.

That concludes my statement. I applaud the Committee for recognizing the importance of LID and green infrastructure to the future management of urban stormwater. The impacts of urban stormwater continue to be critical as our country has been urbanizing at a rate faster than population growth. Thank you for the opportunity to testify. I would be happy to address any questions the Committee might have.

References

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Biographical Sketch

Robert G. Traver

Dr. Robert G. Traver has been a member of the Water Resources and Environmental Engineering Program at Villanova since 1988. He is a registered professional engineer, and a Diplomat of the American Academy of Water Resource Engineers. He teaches graduate courses in hydrology, hydraulics, urban storm water management, and undergraduate courses in all facets of water resources. He is a retired LTC of the US Army Reserves, and a veteran of Desert Storm.

While at Villanova Dr. Traver has conducted research on topics that include modeling of stream hydraulics, urban hydrology, water quality, and measures to mitigate adverse stormwater effects. He constructed the Stormwater Best Management Practice Demonstration and Research Park on the Villanova Campus, and founded the *Villanova Urban Stormwater Partnership* to enable continuing long term stormwater research. Dr Traver believes that research supports and enhances the undergraduate and graduate educational experience.

Immediately after the tragic failure of the New Orleans Hurricane Protection System, Dr Traver was asked to serve on ASCE's External Review Panel (ERP) of the Corps investigation of Hurricane Katrina. He was awarded the Outstanding Civilian Service Medal for his commitment and contribution by the Commanding General of the Corps of Engineers.

Recognizing the link between policy and engineering, Dr. Traver continues to be involved with the implementation of stormwater policy. He participated with a team study to review the effects of Pennsylvania's water regulation on watershed sustainability (1994), and was appointed by the Secretary of PaDep to the oversight committee for Pennsylvania's 2006 Stormwater BMP manual. Dr Traver has served as Chair for the 1998, 1999, 2001, 2003, 2005, and 2007 Pennsylvania Stormwater Management Symposium's held at Villanova. He has recently concluded his work as a member of NRC Committee *Reducing Stormwater Discharge Contributions to Water Pollution,* and has been appointed to the Pennsylvania Department of Environmental Protection Water Resources Advisory Committee.